II. REMARKS

Claims 1-2, 4-28, 31-33, 35-38 and 47-70 are pending. Claims 3, 29-30, 34 and 39-47 have been cancelled, claim 37 (second occurrence) has been renumbered 47, claims 1-2, 4, 13, 18-19, 21-22, 24, 27-28, 33 and 37-38 have been amended, and claims 48-70 have been newly added. Attached hereto is Appendix A showing the changes made to the amended claims. Reconsideration is respectfully requested.

1. New Contact Information

A new power of attorney, signed by the assignee of record in the present case, is submitted herewith authorizing Gray Cary Ware & Freidenrich LLP to prosecute the above identified patent application. Please note the new customer number and contact information:

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New Attorney Docket Number: 2103248-990140

2. Multiple Claims 37

It has been discovered that two different claims were originally filed in this application. The second such claim has been renumbered as claim 47.

3. Objection to Claim 33

Claim 33 was objected to because line 12 thereof allegedly recites "mask 11 layer." However, applicants respectfully submit there is no such recitation in claim 33. It appears the Examiner may have inadvertently included the claim line numbers as part of the claim itself. If this objection is maintained, further explanation of the objection is respectfully requested.

4. Rejection of Claims 1-2, 4-5, 9-10, 12-14, 16-17, 23-27 and 31 Under Section 102

Claims 1-2, 4-5, 9-10, 12-14, 16-17, 23-27 and 31 were rejected under 35 U.S.C. 102(b) as being anticipated by the 1994 publication entitled Bandgap Tuning of Semiconductor

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Quantum Well Structure Using Ion Implantation, Superlattices and Microstructures, Vol. 15, No. 4, (hereinafter "Poole I").

Claim 1 has been amended to recite a method for shifting bandgap energy of a quantum well structure formed over a substrate and including at least an upper barrier layer, a lower barrier layer, and a quantum well layer disposed between the upper barrier layer and the lower barrier layer. The method includes the steps of introducing ions into a quantum well structure at an elevated temperature, wherein the ions are introduced no closer than 0.5 microns from the upper and lower barrier layers, and thermally annealing the quantum well structure, wherein quantum well interdiffusion is induced and the bandgap energy of the quantum well layer is shifted. (See original claim 29, now cancelled.) It is believed that introducing ions no closer than 0.5 microns from the upper/lower barrier layers is novel, especially in combination with ion introduction at an elevated temperature, because it is commonly believed that for effective quantum well interdiffusion, the ions must essentially reach and/or penetrate the barrier layers (see page 386, second column, lines 12+ of Poole I, where implantation creates vacancies "immediately in the vicinity of the QW's"). In contrast, the Applicants have discovered that the needed point defect concentration at the quantum well structure can be achieved by implanting impurities no closer than 0.5 um away from the barrier layers, which helps to further reduce the formation of complex crystal defects at the quantum well layer that can damage the active QW structure layers, and allows for the use of lower energy implantation equipment (see specification, page 7, lines 12-26). Therefore, it is respectfully submitted that claim 1 as amended is not anticipated by Poole I.

It is also submitted that amended claim 1 is not rendered obvious by Poole I. On page 4 of the Office Action, while addressing the obviousness rejection of original claim 29 (which recited the 0.5 micron limitation), the Examiner admits that none of the references explicitly teach an implantation technique where the ions are introduced at least or equal to 0.5 microns away from the quantum well structures. The Examiner goes on to state, however, that such a limitation is obvious "and would be resulted in the modified invention of Poole et al because such results depend on the type of technique or experimental conditions such as implantation energy, or dose or implantation temperature." The Applicants respectfully traverse this

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conclusion. The Examiner's reasoning is unclear from the quoted statement, but it appears the Examiner finds it would have been obvious to modify the implantation energy, dose or temperature to achieve ion implantation for quantum well interdiffusion no closer than the claimed 0.5 microns. Obviousness can only be established by combining or modifying the teachings of the prior art to produce the claimed invention where there is some teaching, suggestion, or motivation to do so found either in the references themselves or in the knowledge generally available to one of ordinary skill in the art. In re Fine, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988); MPEP 2143.01. The Applicants respectfully submit that the Examiner has failed to identify the requisite teaching, suggestion or motivation necessary to modify the teaching of Poole I to render the claimed invention obviousness. Specifically, it is submitted that merely because such results *can* be achieved with the right type of technique or experimental conditions, that such results are not rendered obvious thereby. The mere fact that the prior art may be modified in the manner suggested by the examiner does not make the modification obvious unless the prior art suggested the desirability of the modification. In re Fritch, 972 F.2d 1260, 1266 n. 14, 23 USPQ2d 1780, 1783-4 N.14 (Fed. Cir. 1992); In re Gordon, 733 F.2d 900, 902, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984)

It is therefore submitted that amended claim 1, and claims 2, 4-5, 9-10, 12-14, 16-17, 23-27 and 31 dependent thereon, are not anticipated (or rendered obvious) by Poole I.

5. Rejection of Claims 6-8, 11, 15, 18-22, 28-30, and 32 Under Section 103(a)

Claims 6-8, 11, 15, 18-22, 28-30, and 32 were rejected under 35 U.S.C. 103(a) as being unpatentable over Poole in combination with Holonayak, Lam, and Elman. Claims 29-30 have been cancelled. The remaining rejected claims depend from amended claim 1, which is not considered obvious over Poole I for the reasons set forth above in Part 3. Further, the additions of the Holonayak, Lam, and Elman references do not appear to remedy the shortcomings of Poole I, and thus it is submitted that these claims are allowable.

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6. Rejection of Claims 33-42 Under Section 103(a)

Claims 33-42 were rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent 6,027,989 ("Poole II") in combination with Poole I. Claims 34 and 39-47 have been cancelled. Claims 33 and 35-38 have been amended to depend from claim 1, which is deemed allowable for the reasons set forth above in Part 3.

7. Newly Added Claims

Claims 48-70 have been newly added to more clearly define what the Applicants regard as the invention. It is respectfully submitted that these new claims are allowable over the prior art cited by the Examiner, and that no new matter has been added.

Specifically, claim 48 recites, inter alia, that the ions are introduced into the quantum well structure at an elevated temperature and with an implantation energy of no more than 400 KeV. This combination is supported in the specification by, for example, on page 13, lines 20-32, and on page 33, lines 6-10. It is submitted that the combination of the elevated implant temperature and low implant energy is not taught or suggested by the cited prior art references. Specifically, with low implant energies, the benefits of an elevated implant temperature are believed to be unknown, and therefore unused. This is evident from the Poole I reference, where two experiments are reported. In the first experiment (entitled low energy implantation), 100 KeV implantation was performed WITHOUT an elevated implantation temperature. In the second experiment (entitled high energy implantation), 8 MeV implantation was performed WITH an implantation temperature as high as 200°C. Therefore, it is respectfully submitted that claim 48, and claims 49-59 dependent thereon, are allowable.

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Claim 60 recites the combination of ion implantation at an elevated temperature, an implant energy not exceeding 400 KeV, and the implantation of ions no closer than 0.5 um to the barrier layers. For the reasons stated above, it is submitted that the combination of limitations in claim 60 is novel and unobvious, and this thus allowable (along with claims 61-62 dependent thereon).

Claims 63-70 recite varying the dosage and/or implant energies of the ions to vary the band gap energy shifts in different predetermined portions of the quantum well structure, to form

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passive and active optical devices (such as an optical switch). See, for example, page 37, lines 27+, and Fig. 9.

For the foregoing reasons, it is respectfully submitted that the claims are in an allowable form, and action to that end is respectfully requested.

Respectfully submitted,

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Dated: Dec. 27, 2002 By: [signature]

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APPENDIX A: MARKINGS TO SHOW CHANGES MADE

1. (Amended) A method for shifting the bandgap energy of a quantum well layer comprising:

introducing ions into a quantum well structure at an elevated temperature [and a dose of greater than $1x10^{12}$ cm^{-2}], wherein the quantum well structure is formed over a substrate and includes at least [comprising]:

an upper barrier layer;

a lower barrier layer; and

a quantum well layer disposed between the upper barrier layer and the lower barrier layer; and wherein the ions are introduced no closer than 0.5 microns from the upper and lower barrier layers; and

thermally annealing the quantum well structure;

[whereby] wherein quantum well interdiffusion is induced and the bandgap energy of the quantum well layer is shifted.

t 2. (Amended) The method of claim 1, wherein the elevated temperature is in the range of from about 200 °C to near the crystal damage temperature.

Claim 3 cancelled.

4. (Amended) The method of claim 1, wherein the introducing step creates crystal site vacancies in the quantum well structure at a concentration below $6x10^{19}$ cm^{-3}.

13. (Amended) The method of claim 12 [further comprising, during the introducing step, introducing a deep-level ion species] wherein the introduced ions are selected from [the] a deep-level ion species group consisting of oxygen, gallium, fluorine, nitrogen, boron and argon.

18. (Amended) The method of claim 1 [further comprising, during the introducing step, introducing ions into a] wherein:

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the quantum well structure [that] further includes [:] an upper cladding layer disposed above the upper barrier layer; and

the introducing step includes introducing [impurity] the ions into the upper cladding layer.

19. (Amended) The method of claim 1 [further comprising, during the introducing step, introducing ions into a] wherein:

the quantum well structure [that] further includes[:] an upper cladding layer disposed above the upper barrier layer; and

the introducing step includes introducing [impurity] the ions into the upper cladding layer such that the impurity ions are at least 0.5 micron from the upper barrier layer.

21. (Amended) The method of claim 20, wherein the thermally annealing step is conducted at a temperature above 600 °C, and wherein the [further comprising, during introducing step, introducing ions into a InP-containing] quantum well structure contains InP.

22. (Amended) The method of claim 21, wherein the thermally annealing step is conducted at a temperature above 700 °C, and wherein the [further comprising, during the introducing step, introducing ions into a GaAs-containing] quantum well structure contains GaAs.

24. (Amended) The method of claim [23] 1, wherein the introducing step employs an implantation [energy in the range of 1 eV to 3 MeV] dosage of greater than $1x10^{12}$ cm^{-2}.

27. (Amended) The method of claim 1 further comprising, after the introducing step and before the thermal annealing step, depositing a capping layer on [the] an upper surface of the quantum well structure.

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28. (Amended) The method of claim 1, wherein the [further comprising, during the introducing step, introducing ions into a] quantum well structure [that] further includes a layer doped with a high mobility impurity[, the layer doped with a high mobility impurity being] and is back-spaced by at least 0.1 μm from at least one of the quantum well layer, the upper barrier layer and the lower barrier layer.

Claims 29-30 cancelled.

33. (Amended) The [A] method of claim 1, further [for shifting the bandgap energy of a predetermined portion of quantum well layer] comprising the step of:

forming a patterned mask layer [on a] over the quantum well structure[, the quantum well structure including:

a first barrier layer;

a second barrier layer; and

a quantum well layer disposed between the first barrier layer and the second barrier layer];

wherein the implanting step includes implanting the ions into a predetermined portion of the quantum well structure, at a temperature in the range of from about 200 °C to about 700 °C, using the patterned mask layer as an implant mask; and

[thermally annealing the quantum well structure,

whereby] wherein the quantum well interdiffusion is induced and the bandgap energy of the predetermined portion of the quantum well layer is shifted.

Claim 34 cancelled.

[37] 47. (Amended) The method of claim 36 further comprising, during the forming step, forming [a] the patterned mask layer that includes a plurality of patterned mask layer portions, each of the plurality of patterned mask layer portions having a thickness that is different than the thickness of the other patterned mask layer portions, and during the implanting

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step, implanting ions into predetermined portions of the quantum well structure using the patterned mask layer to control the penetration of ions into the predetermined portions of the quantum well structure.

38. (Amended) The [A] method of claim 33, [for shifting the bandgap energy of a predetermined portion of a quantum well layer comprising:

forming a patterned stress-inducing mask layer on a quantum well structure;

implanting ions into a predetermined portion of the quantum well structure at an elevated temperature, using the patterned stress-inducing mask layer as an implant mask; and

thermally annealing the quantum well structure,

whereby] wherein the quantum well interdiffusion is induced and the bandgap energy of the predetermined portion of the quantum well structure is shifted with a spatial resolution of less than 3 microns.

Claims 39-46 cancelled.

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